Remote Sensing of Human Impact on the Position and Structure of the Northern Treeline
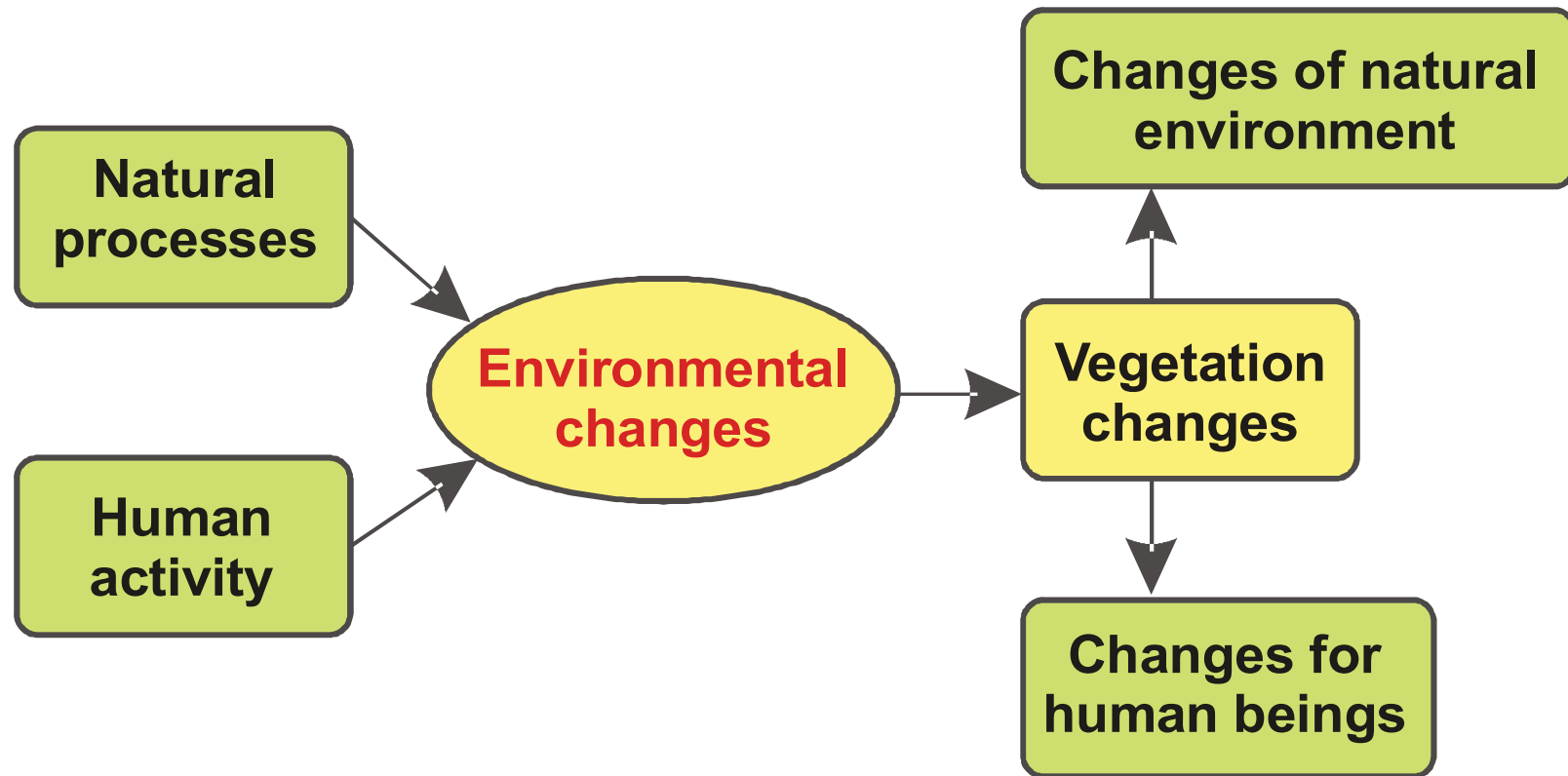
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Volkovo village, Zvenigorod, Russia · 14 – 17 April 2009

➢ Relationship between human impact on vegetation and its feedback of vegetation??
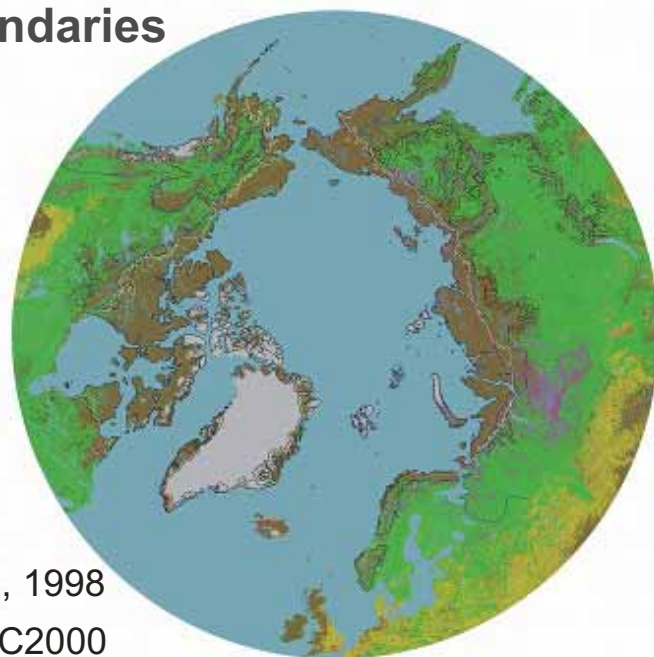
Study area: Northern Europe

> Most industrially developed region of the Arctic and Sub-Arctic

> Significant human impact on its vegetation in forest, pre-tundra and tundra zones

> Possibly a link between human activity and the position and structure of treeline

Geographical Location

Finland
Russia
Sweden
Norway

Study area
Arctic circle, Latitude: 66 33'39" N
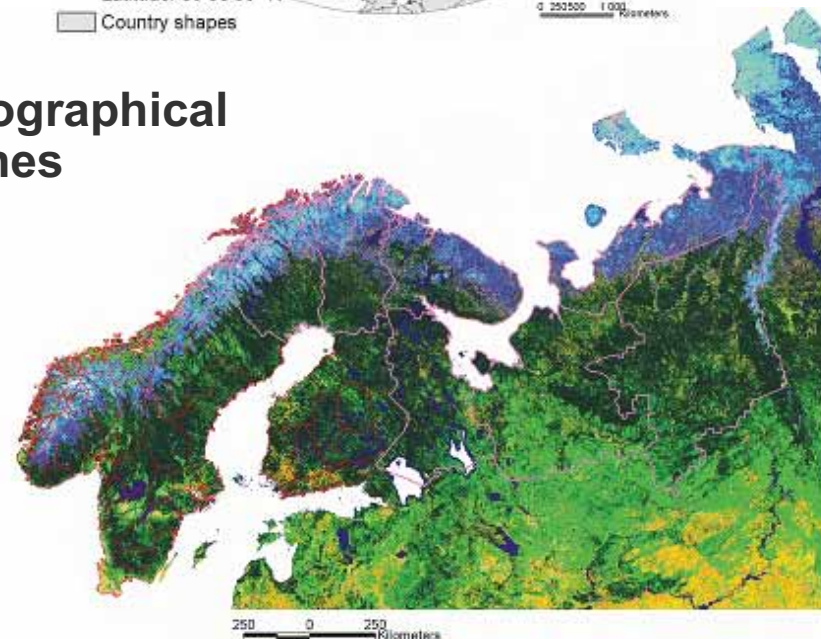Country shapes

0 250 500 1 000 Kilometers

Forest Boundaries

Hustich, 1983:
— birch;
— evergreen conifer;
— larch

CAVM, 2003
— Olson & Dinerstein, 1998

Background: JRC GLC2000

Geographical Zones

250 0 250 Kilometers

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Human impact: hotspot test areas
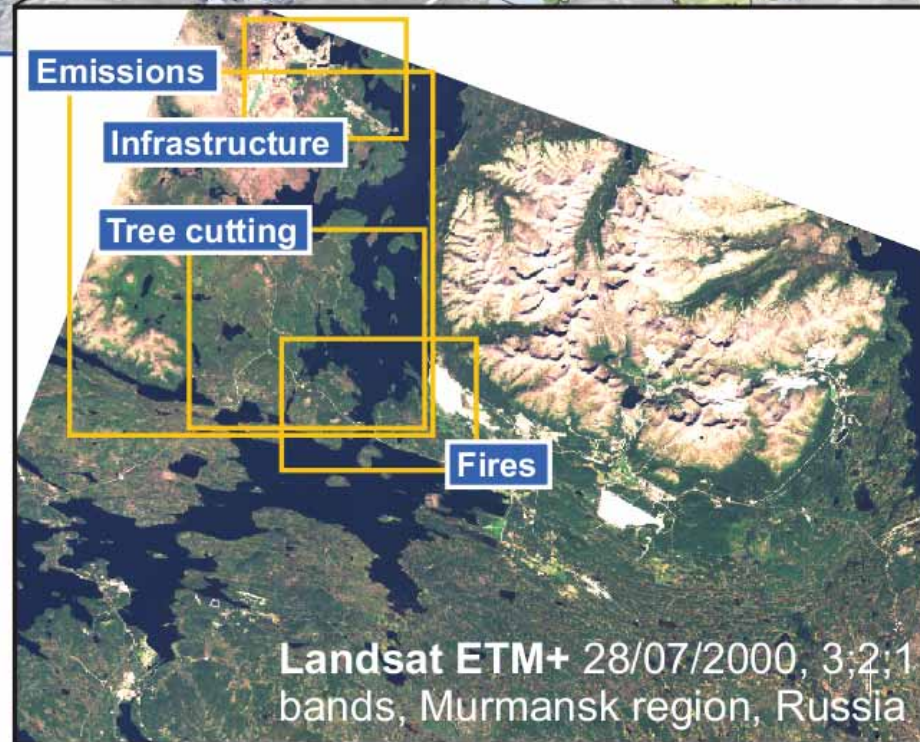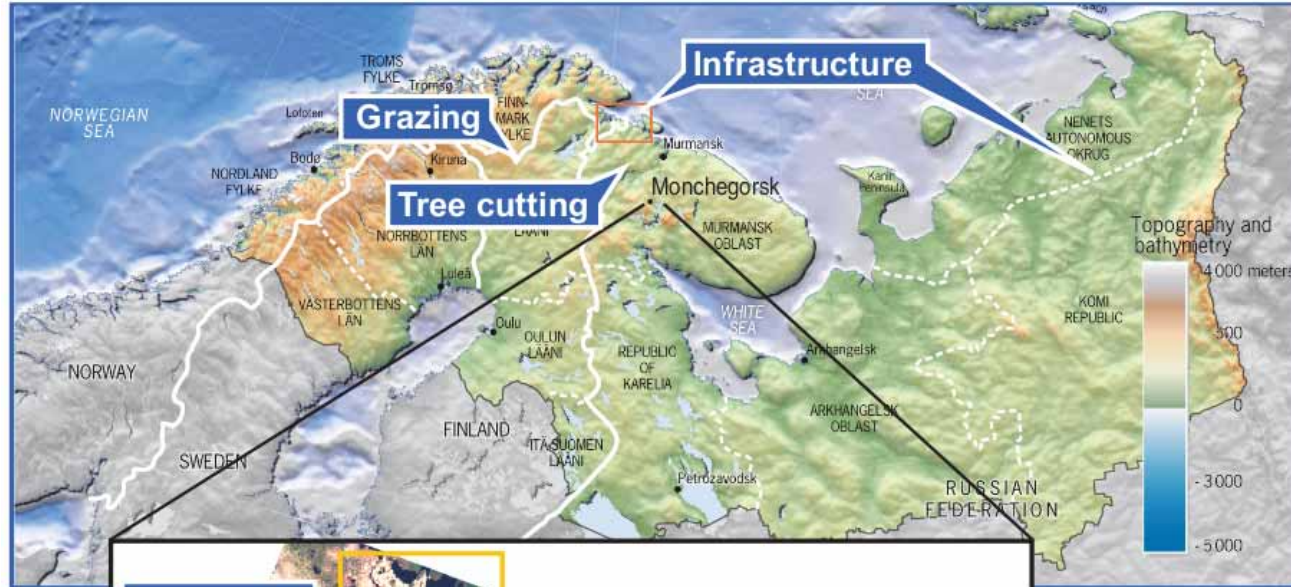
Types of human impact:

›Industrial atmospheric pollution

›Fire

›Mining extraction, urbanisation/ infrastructure, gas and oil development

›Grazing

›Logging

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Types of human impact: atmospheric emissions

➢ Emissions of sulphur dioxide and heavy metals have adverse effect on physiological processes of plants

➢ Transported over long distances, accumulate and migrate in the ecosystem's components

➢ Main source: copper-nickel smelters

Landsat MSS 28/06/1978

Landsat ETM+ 28/07/2000

Monchegorsk, Murmansk Region, Russia

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Human impact: fires

Landsat 5 TM 10/06/1992

Landsat 7 ETM+ 17/07/1999

Landsat 7 ETM+ 30/07/2004
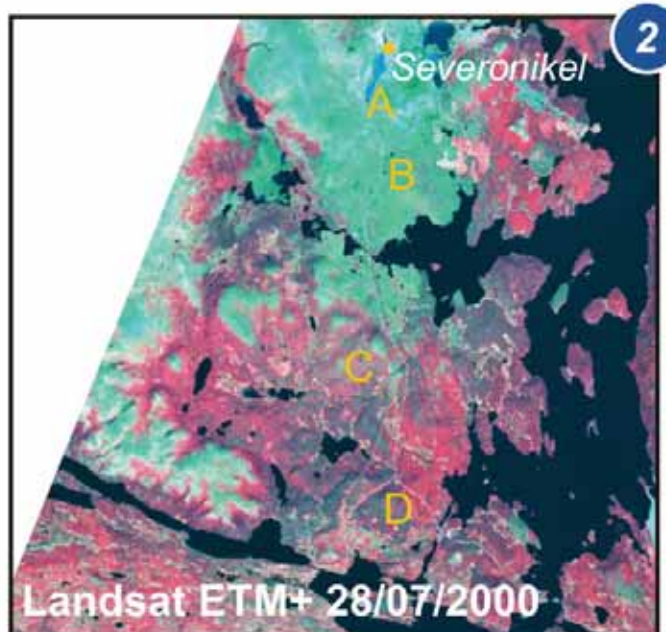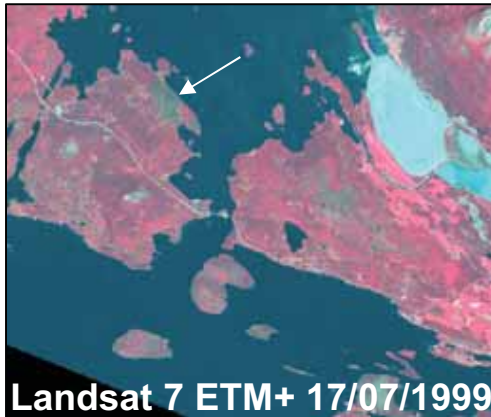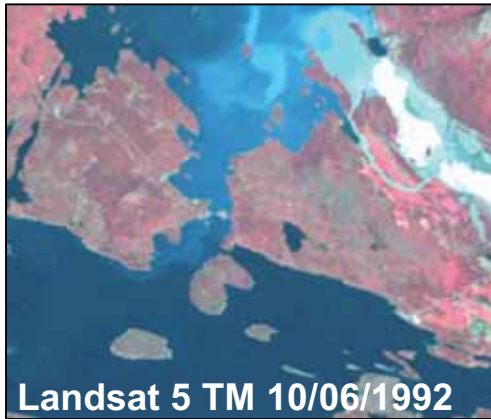
➢ Natural causes: lightnings, dry seasons, etc.

➢ Result from human activity: BBQs, industrial emissions, etc.

Information on fires retrievable by remote sensing:

➢ locations
➢ areas
➢ boundaries
➢ regimes
➢ regeneration of plants

Monchegorsk, Murmansk region, Russia

A

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Human impact: infrastructure, mining, oil and gas development

Landsat TM 13/07/1993

A
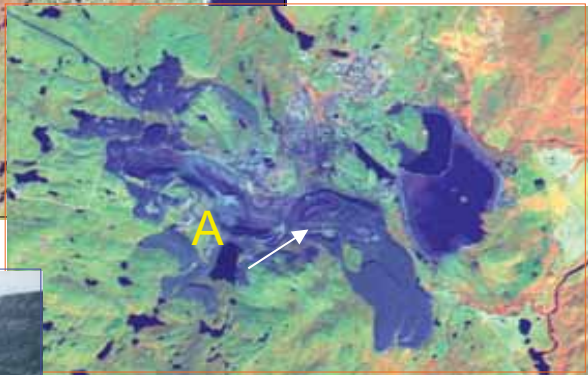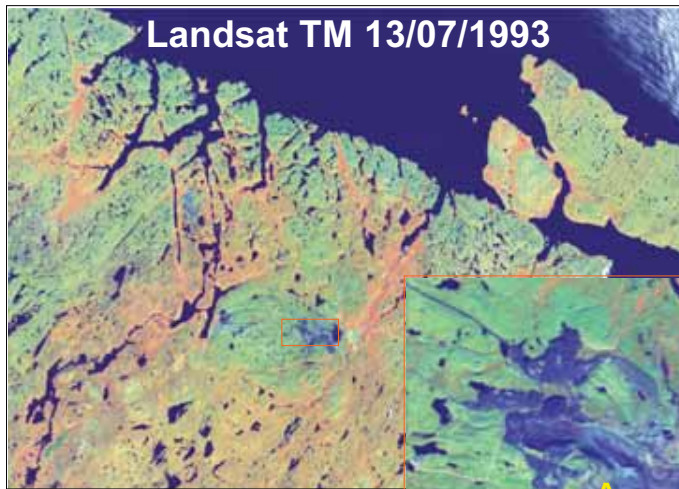
Zapolyarniy, Murmansk region, Russia

Landsat 7 ETM+ 29/06/2007

Usinsk, Komi Republic, Russia

- ➤ Requirement of physical removal of trees.
- ➤ It is reflected on remote sensing data well.

Human impact: logging

- Recent and old logging areas are detectable from remote sensing data.

- Easy to detect recent cutting areas due to their straight boundaries.

- Analysis by manual digitising takes a lot of time.

Kovdor, Murmansk region, Russia

A

Landsat 7 ETM+ 26/07/2000

A

Monchegorsk, Murmansk region, Russia

B

Landsat 7 ETM+ 28/07/2000

B

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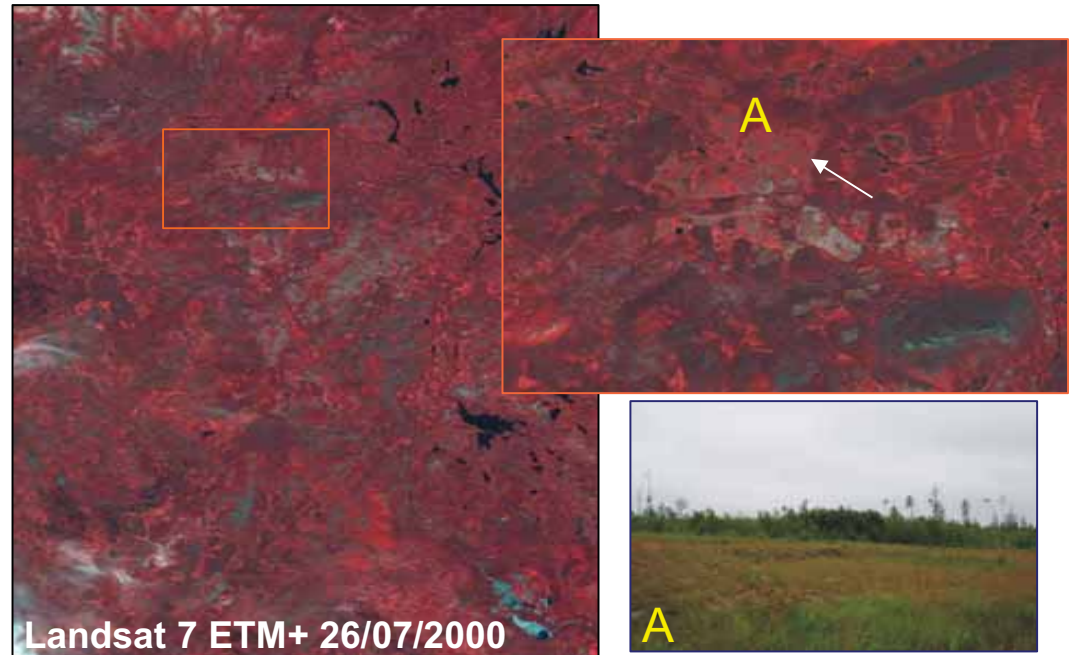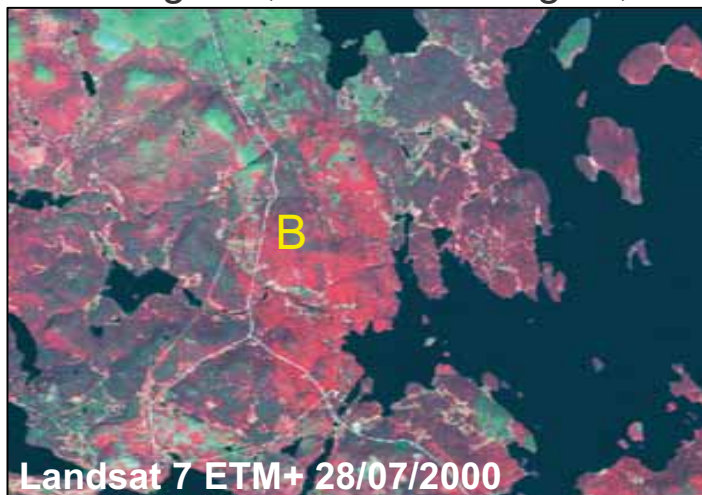
Human-mediated impact: grazing

- ➢ Destruction of plant community structure through incorrect grazing management.

- ➢ Mapping grazing through biomass estimates, NDVI, LAI, classification, etc.

Landsat 7 ETM+
27/07/2000

Norway-Finland
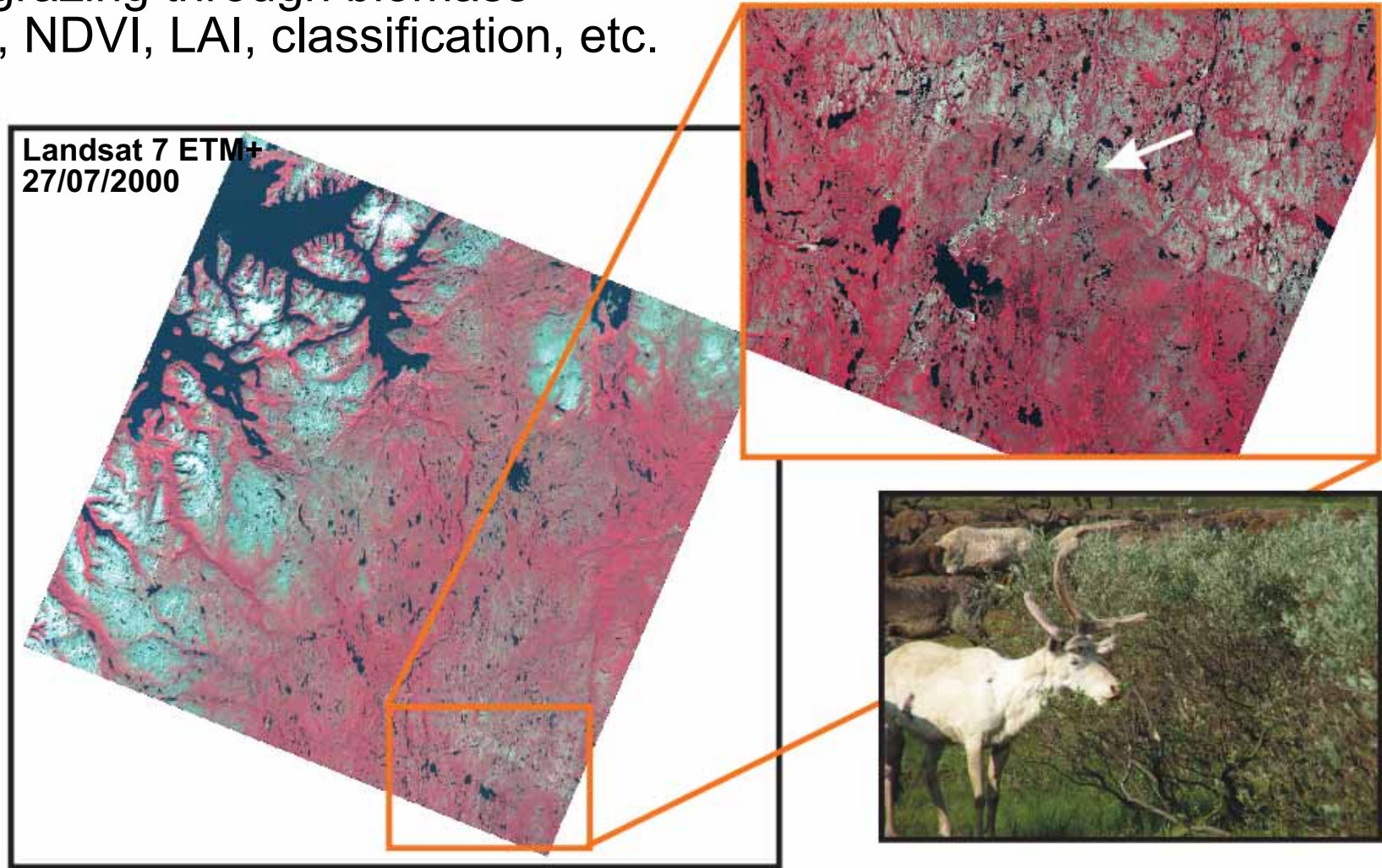
Computer analysis: NBR, image classification

- ➢ Human impact are shown in multi-spectral and multi-temporal images clearly.

- ➢ Non-vegetated areas can easily be identified visually in multi-spectral images.

- ➢ In some cases this process can be automated.

- ➢ Monitoring it and mapping the distribution of the state of vegetation on remote areas.

- ➢ Detailed computer processing of images requires extra data.

Hybrid classification

Legend

Forest
1. Technogenic barren (areas devoid of vegetation in the area with the strongest industrial impact)
1.1 without vegetation
1.2 almost without vegetation
2. Severely damaged forest (80-100 % dead trees)
3. Mostly damaged (60-80% dead trees), predominantly coniferous forest
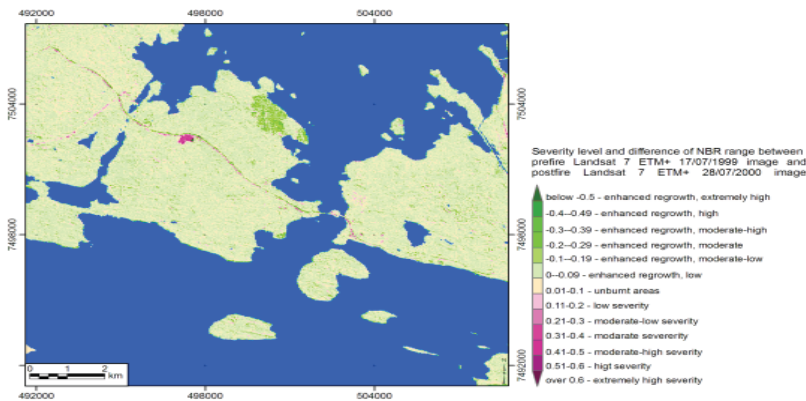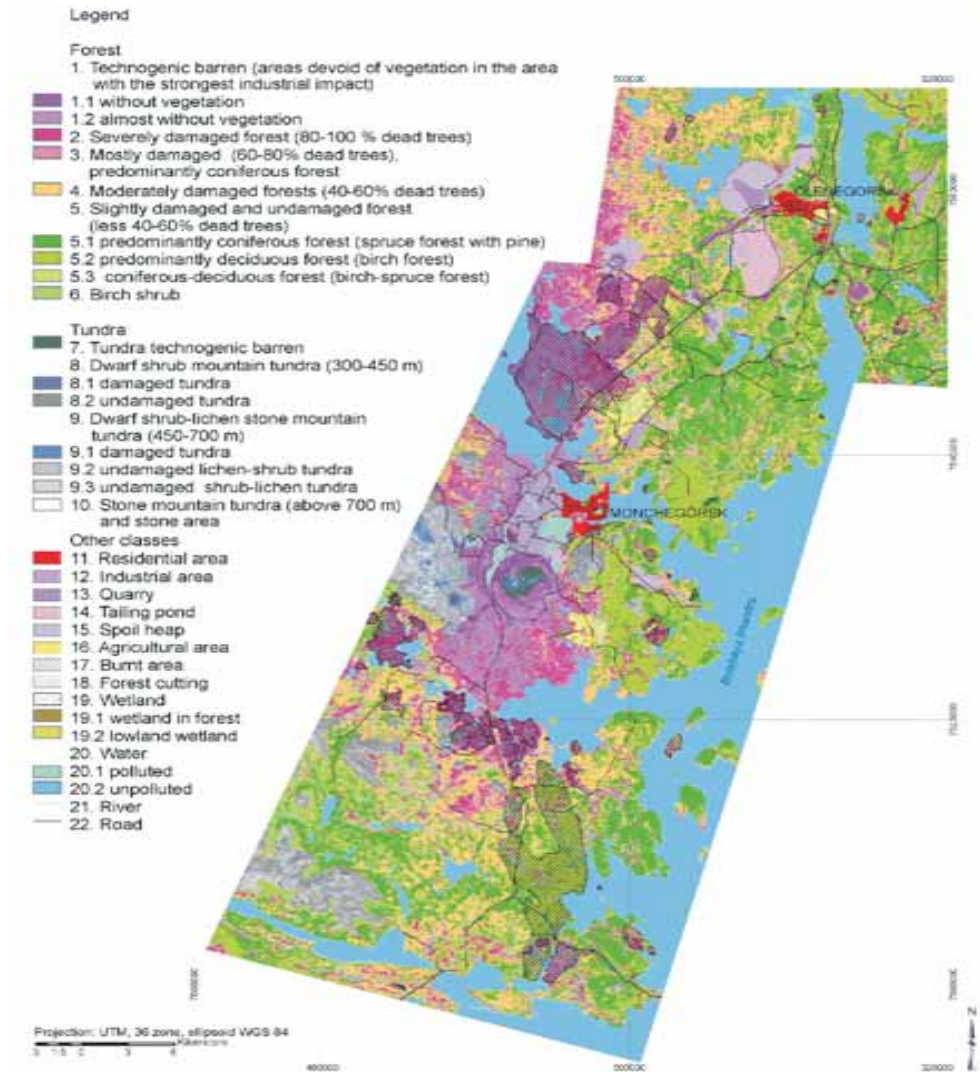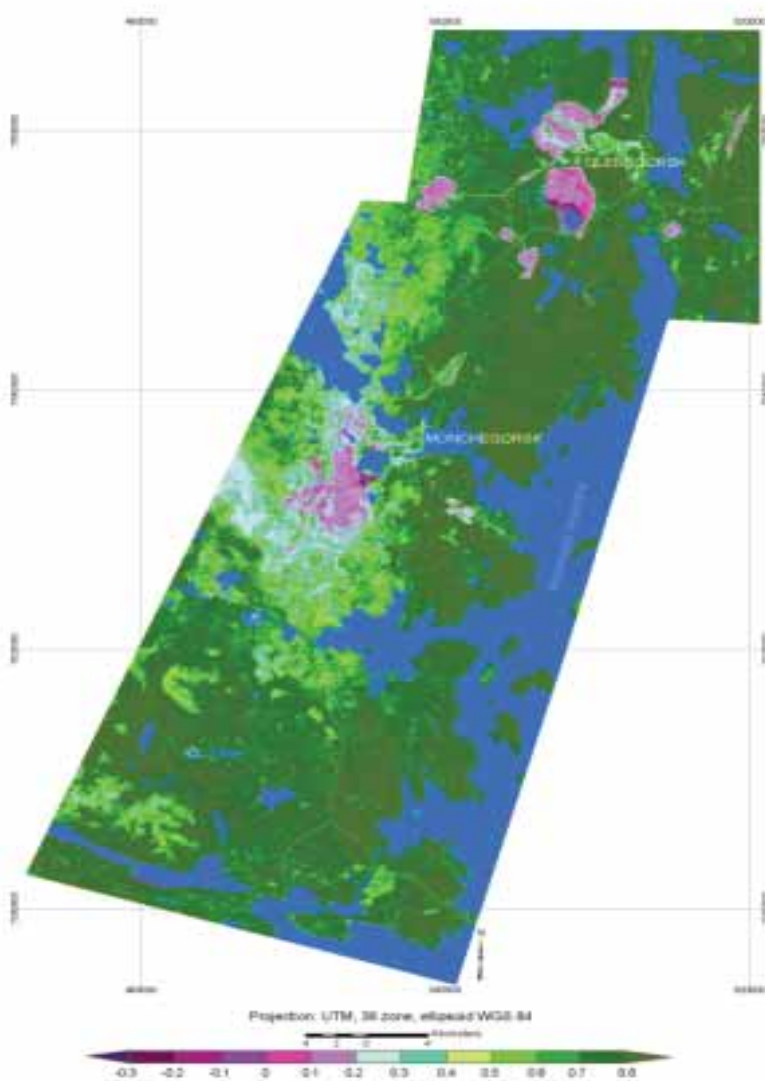4. Moderately damaged forests (40-60% dead trees)
5. Slightly damaged and undamaged forest (less 40-60% dead trees)
5.1 predominantly coniferous forest (spruce forest with pine)
5.2 predominantly deciduous forest (birch forest)
5.3 coniferous-deciduous forest (birch-spruce forest)
6. Birch shrub

Tundra
7. Tundra technogenic barren
8. Dwarf shrub mountain tundra (300-450 m)
8.1 damaged tundra
8.2 undamaged tundra
9. Dwarf shrub-lichen stone mountain tundra (450-700 m)
9.1 damaged tundra
9.2 undamaged lichen-shrub tundra
9.3 undamaged shrub-lichen tundra
10. Stone mountain tundra (above 700 m) and stone area

Other classes
11. Residential area
12. Industrial area
13. Quarry
14. Tailing pond
15. Spoil heap
16. Agricultural area
17. Burnt area
18. Forest cutting
19. Wetland
19.1 wetland in forest
19.2 lowland wetland
20. Water
20.1 polluted
20.2 unpolluted
21. River
22. Road

Projection: UTM, 36 zone, ellipsoid WGS-84

Severity level and difference of NBR range between prefire Landsat 7 ETM+ 17/07/1999 image and postfire Landsat 7 ETM+ 28/07/2000 image

below -0.5 - enhanced regrowth, extremely high
-0.4–-0.49 - enhanced regrowth, high
-0.3–-0.39 - enhanced regrowth, moderate-high
-0.2–-0.29 - enhanced regrowth, moderate
-0.1–-0.19 - enhanced regrowth, moderate-low
0–0.09 - enhanced regrowth, low
0.01-0.1 - unburnt areas
0.11-0.2 - low severity
0.21-0.3 - moderate-low severity
0.31-0.4 - moderate severerity
0.41-0.5 - moderate-high severity
0.51-0.6 - higt severity
over 0.6 - extremely high severity

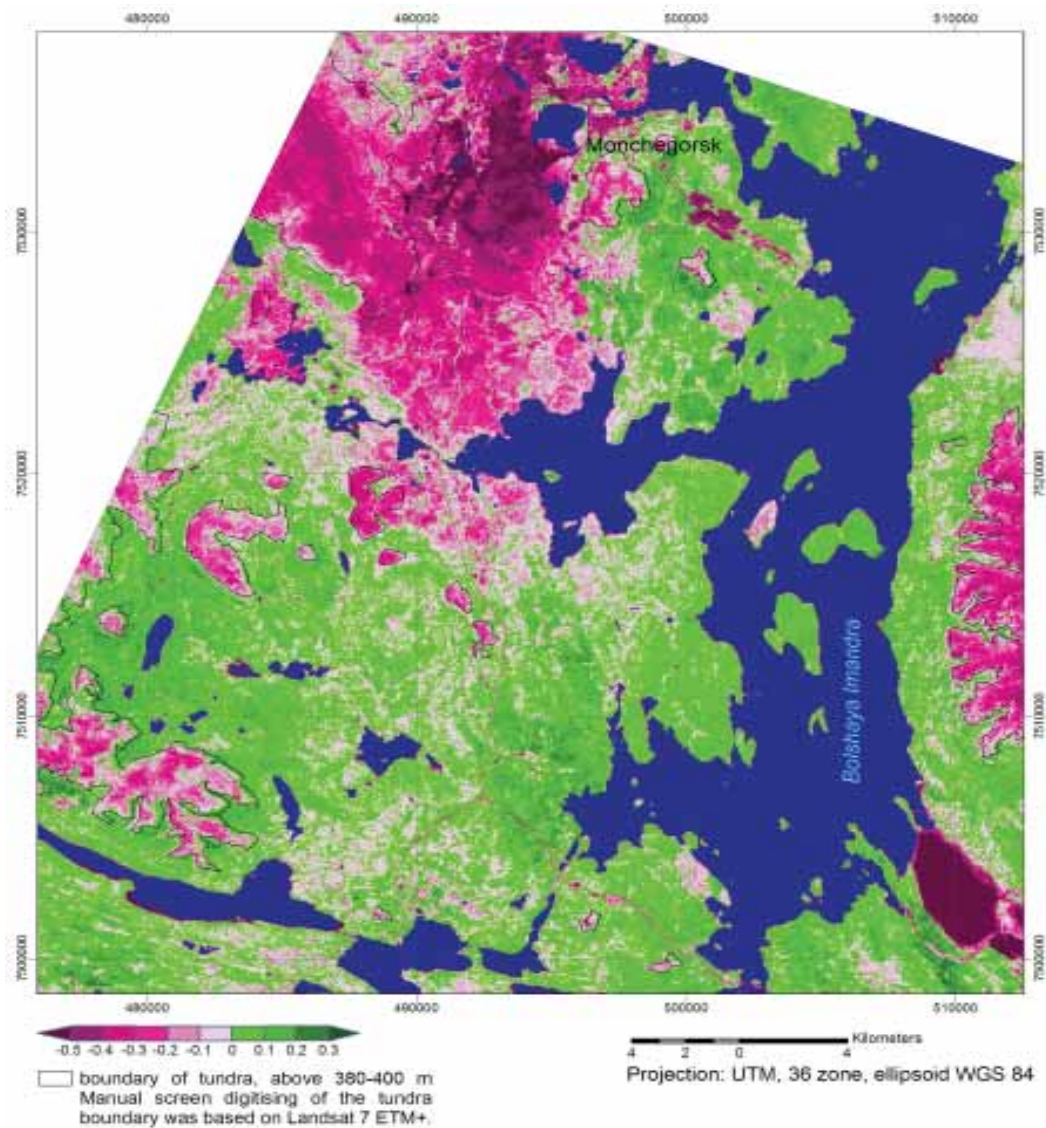## Normalised Burn Ratio

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Computer analysis: vegetation indices

NVDI mapping of air pollution impact

NDVI difference of real and modelled NDVI

Outlook and future work

- Identification of human hotspots close to the treeline;

- Selection of automated methods for the detection of human impact of different types;

- Determination of the most appropriate computer methods for the detection of each type of human impact using remote sensing data;

- Development of computer methodology for the detection of human hotspots based on remote sensing;

- Creation of a map showing the position and structure of the treeline in the areas of human impact.

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Thank you

Photos by the authors and
A. Miheeva, 2004, 2007

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